# COST-EFFECTIVE CONTROL OF $NO_x$ WITH INTEGRATED ULTRA LOW-$NO_x$ BURNERS AND SNCR

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## SUMMARY

Under sponsorship of the Department of Energy's National Energy Technology Laboratory (NETL), McDermott Technology, Inc. (MTI), the Babcock & Wilcox Company (B&W), and Fuel Tech teamed together to investigate an integrated solution for $NO_x$ control. The system was comprised of B&W's DRB-4Z™ ultra low-$NO_x$ pulverized coal (PC) burner technology and Fuel Tech's $NO_x$OUT®, a urea-based selective non-catalytic reduction (SNCR) technology.

Development of the low-$NO_x$ burner technology has been a focus in B&W's combustion program. The DRB-4Z™ burner is B&W's newest low-$NO_x$ burner capable of achieving very low $NO_x$. The burner is designed to reduce $NO_x$ by controlled mixing of the fuel and air.

Based on data from several 500 to 600 $MW_e$ boilers firing PRB coal, $NO_x$ emissions levels of 0.16 to 0.20 lb/ $10^6$ Btu have been achieved from the DRB-4Z™ burners in combination with overfire air ports. Although $NO_x$ emissions from the DRB-4Z™ burner are nearing the Ozone Transport Rule (OTR) level of 0.15 lb $NO_x/10^6$ Btu, the utility boiler owners can still benefit from the addition of an SNCR and/or SCR system in order to comply with the stringent $NO_x$ emission levels facing them.

Large-scale testing was conducted in B&W's 100-million Btu/hr Clean Environment Development Facility (CEDF) that simulates the conditions of large coal-fired utility boilers. The one-of-a-kind facility is equipped with one near full-scale burner. The CEDF is constructed with water walls and is

insulated with refractory to simulate the thermal conditions of the middle row burner in a commercial boiler.

A wide range of commercially available utility coals including Spring Creek, a Montana high-volatile subbituminous coal from Powder River Basin (PRB) region, Pittsburgh #8 high- volatile bituminous coal, and Middle Kittanning medium-volatile bituminous coal were tested. Under the most challenging boiler temperatures and residence time conditions at full load, the DRB-4Z™ burner alone (without air staging) achieved $NO_x$ emissions of 0.26 lb/$10^6$ Btu for PRB coal, 0.30 for Pittsburgh #8, and 0.40 for Middle Kittanning coal. The $NO_x$ variations with fuel can be explained with the fuel ratio (fixed carbon over volatile matter, FC/VM) and fuel nitrogen content. Low-$NO_x$ burners generate lower $NO_x$ in the near burner zone by the conversion of volatile nitrogen compounds to molecular nitrogen. Therefore, the $NO_x$ emissions from coals with higher volatile matter, or lower FC/VM tend to be lower. Fuel ratios for Spring Creek, Pittsburgh #8, and Middle Kittanning were 1.26, 1.19, and 2.38 respectively. In addition, the lower fuel nitrogen content and higher moisture with the Spring Creek coal reduced the overall $NO_x$ emissions.

In order to determine the optimum SNCR port locations, numerical modeling and measurements of in-furnace temperature and gaseous species were performed. The furnace exit gas temperature (FEGT) was 2123 F at full load when firing Spring Creek coal. FEGT increased with Middle Kittanning coal to 2297 F due to its lower volatile content and more char to burn further downstream in the gas flow path. The SNCR port locations at 4 different elevations were used for parametric testing.

The baseline $NO_x$ levels at full load were reduced by the SNCR system (configured with wall injectors only) to 0.19, 0.22, and 0.32, respectively. Under the more favorable high-residence time conditions at reduced loads, $NO_x$ emissions were lower for both baseline (burner only) and SNCR operation. Baseline $NO_x$ emissions of 0.17 lb/$10^6$ Btu for PRB coal at 60 million Btu/hr were reduced to 0.13 lb/$10^6$ Btu by SNCR. The lowest $NO_x$ of 0.09 lb/$10^6$ Btu was achieved at a 40 million Btu/hr firing rate. These data were obtained while the ammonia slip was below 5 ppm. Higher reductions were possible when the ammonia slip was between 5 to 10 ppm.

In summary, the testing has provided evidence that SNCR technology can complement the $NO_x$ reduction attainable with ultra low-NOx burner technology. The DRB-4Z™ low-$NO_x$ burner produced low $NO_x$ without air staging (no OFA). Additional $NO_x$ reduction could be obtained by air staging. Significant $NO_x$ reductions were demonstrated from very low baselines by SNCR while controlling ammonia slip to less than 5 ppm. Improved performance may be possible with convective pass injection at full load. Capital and operating costs will be presented in the context of benefits derived from the combination of ultra low-$NO_x$ burner and SNCR or SCR.